“Digital innovation and performance of student startups in Peru: A PLS-SEM evaluation”

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DIGITAL INNOVATION AND PERFORMANCE OF STUDENT STARTUPS IN PERU: A PLS-SEM EVALUATION

Abstract

Digital innovation is critical to the competitiveness of university-based startups in emerging economies, yet empirical evidence contextualized to Peru remains limited. This study analyzes the effect of digital innovation, operationalized through digital marketing, process automation, and data analytics, on the performance of university startups in Peru using the PLS-SEM technique. We employed a quantitative design with a structured survey administered to founders or managers of 100 student startups affiliated with incubation programs at two private universities in Lima; the sample was selected for relevance (active operations and engagement with digital tools). Data were collected between August and November 2024 using multi-item Likert questionnaires. Reliability and validity were assessed with standard PLS-SEM criteria, and structural paths were evaluated via bootstrapping (5,000 resamples). Results indicate that digital marketing increases competitiveness ($\beta = 0.54$; $p < .001$), process automation improves operational efficiency ($\beta = 0.41$; $p < .001$), and data analytics strengthens strategic adaptability ($\beta = 0.48$; $p < .001$). Additionally, 56% of startups report financing constraints as the main barrier to digital transformation, followed by insufficient digital training (22%) and limited access to technology (15%). Taken together, these findings suggest that university incubators in resource-constrained contexts can enhance startup performance by prioritizing targeted financing instruments, hands-on training in automation and analytics, and affordable access to technology.

Keywords digital innovation, digital marketing, process automation, data analytics, startups, PLS-SEM

JEL Classification O32, M13, L26, I23

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INTRODUCTION

Digital innovation has become a key driver of competitiveness for ventures in their early stages, especially within university ecosystems in emerging economies. Among student startups, the adoption of digital marketing, process automation, and data analytics promises shorter learning cycles, higher operational efficiency, and stronger strategic responsiveness (Vasquez-Reyes & Cordova-Buiza, 2024). In Peru, however, persistent constraints in financing, training, and access to technology complicate effective adoption. This gap between the potential attributed to digital capabilities sustains both scholarly and practical interest (Ferruz Gonzalez & Claro Montes, 2025).

This context raises a clear scientific problem: to determine under what conditions and with what intensity core digital innovation capabilities translate into observable improvements in the performance of student startups operating within Peruvian universities. The evidence available for the country remains fragmented and often extrapolated from more mature ecosystems, which limits external validity and the usefulness of prior conclusions for decision-making in incubation programs (Vasquez-Reyes & Cordova-Buiza, 2024). At the same time,

structural barriers related to capital, infrastructure, and specialized human resources coexist with local enablers such as academic networks, mentoring, and access to niche markets. These mixed conditions suggest that the effects of digital innovation may be heterogeneous depending on the capability emphasized and each venture's operating context (Djellal et al., 2013; Baron, 2007).

Therefore, this study investigates the extent to which digital marketing, process automation, and data analytics translate into measurable performance gains for student startups in Peru. By focusing on a resource-constrained university context, the study provides policy-relevant evidence on how digital capabilities shape competitiveness, efficiency, and strategic adaptability.

1. LITERATURE REVIEW AND HYPOTHESES

In the context of university startups, the advantages and opportunities associated with digital innovation coexist with persistent structural challenges. These firms often operate with limited resources and within academic cultures that do not always prioritize the development of digital skills (Montes et al., 2023; Heredia Perez et al., 2019). At the same time, they benefit from distinctive assets such as access to academic networks and knowledge infrastructures that can enable innovation effectively (Belz & Binder, 2017; Hanelt et al., 2021). Within universities, digital innovation can shape how students launch and scale their ventures and can foster a culture of continuous learning and technological adaptation. Prior research shows that implementing digital technologies in university ecosystems enhances the performance of individual startups and strengthens broader entrepreneurial frameworks through collaboration among students, faculty, institutions, and external stakeholders (Liu et al., 2021; Arranz et al., 2019; Benítez et al., 2020).

Globally, startups have leveraged digitalization to access new markets, reduce operating costs, and overcome traditional barriers to entry. Among the most impactful technologies are digital marketing, process automation, and data analytics, which contribute to operational optimization, customer responsiveness, and evidence-based decision-making (Wei & Ling, 2006; Barney, 2001). These tools help entrepreneurs understand consumer behavior and changing market dynamics, which improves adaptability. For university startups, they are even more critical given typical resource constraints and limited managerial experience (Assink, 2006; Kumar et al., 2016; Davidsson, 2016; Del Carpio Gallegos & Seclén-Luna, 2022).

Despite these advantages, technological transformation in university startups, particularly in emerging economies, is often hampered by systemic barriers (Vasquez-Reyes & Cordova-Buiza, 2024). The literature consistently identifies constraints such as restricted access to finance, insufficient technical training, and limited institutional support for digital entrepreneurship (Hair et al., 2021; Cunneen et al., 2007). In Latin America, these challenges are compounded by uneven infrastructure and technological ecosystems. In Peru, structural barriers that include limited funding for innovation systems and the absence of comprehensive digital training significantly restrict entrepreneurial capacity at the university level (PRODUCE, 2020; Gunday et al., 2011; Zahra & Nambisan, 2012).

This context also creates an opportunity to examine how digital innovation can be harnessed in environments with constrained resources. Universities can play a pivotal role by providing access to digital tools, training programs, and spaces for experimentation, which can serve as catalysts for venture development (Bogers et al., 2018; Autio et al., 2014; Phadke & Vyakarnam, 2017). A growing body of papers advocates a systemic and ecosystem-based approach to digital entrepreneurship in which universities collaborate with public and private sectors to address gaps in infrastructure and resources (Yoo et al., 2010; Audretsch & Belitski, 2023; Cooper, 2008).

Advancing digital entrepreneurship in universities requires moving from isolated educational interventions to integrated institutional strategies that promote inclusive and sustainable innovation. Priority actions include embedding digital literacy across curricula, developing mentoring programs with industry experts, and supporting innova-

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tion projects led by faculty members (Bogers et al., 2018; Markovic et al., 2021). Policymakers also have an important role through financing mechanisms, tax incentives for emerging technology firms, and investment in university innovation centers (Parida et al., 2019). In this setting, coordinated collaboration among academia, the productive sector, and government can create conditions that turn students' digital aspirations into viable and sustainable ventures (Howells, 2006; Moroz & Hindle, 2012; Caloffi et al., 2023).

Inclusive digital transformation should be a priority so that underrepresented student populations, including women, rural students, and economically disadvantaged groups, have equitable access to digital resources and entrepreneurship training (Yoo et al., 2010). Without deliberate inclusion policies, digital innovation can widen existing inequalities in academia and business (Moroz & Hindle, 2012; Álvarez & Seclén, 2023). Equity-oriented digital strategies are therefore essential to ensure that all university entrepreneurs benefit from technological advances and contribute to national development goals (Parida et al., 2019; Acs et al., 2014).

Beyond institutional and policy efforts, rigorous evaluation frameworks are needed to monitor the effectiveness of digital innovation strategies in university settings (Howells, 2006). Longitudinal assessments of startup growth, innovation outputs, and market performance can reveal the real impact of digital tools and can inform adaptive policies and continuous improvement of support systems (Yoo et al., 2010; Kuratko, 2020). Feedback loops involving founders, incubators, and investors help align institutional offerings with entrepreneurs' actual needs. Combining academic insight with market responsiveness is essential to sustain meaningful innovation (Sarasvathy, 2001).

Digital innovation should also be understood as a cultural shift within academic institutions rather than only a technical upgrade. Fostering an entrepreneurial mindset, comfort with risk, interdisciplinary collaboration, and openness to change is essential for the successful integration of digital solutions (Cordova-Buiza et al., 2022; Moroz & Hindle, 2012). Universities can cultivate environments that encourage experimentation and tolerate failure, especially in contexts such as Peru, where risk aversion can become a cultural barrier (Sarasvathy, 2001). Integrating this culture of innovation into administrative structures, academic programs, and institutional missions can consolidate the university as a dynamic incubator of new digital firms (Van de Vrande et al., 2009; Von Hippel, 2005).

The literature points to the strategic value of digital innovation for strengthening university-affiliated startups, particularly through digital marketing, process automation, and data analytics, which improve operational efficiency, inform decision making, and enhance competitiveness (Arnold & Wade, 2015; Wei & Ling, 2006; Tidd & Bessant, 2013; Porter & Stern, 2001). Much of this evidence comes from mature technological ecosystems, which limit transferability to emerging economies where structural, cultural, and economic conditions shape implementation (Sarasvathy, 2001; Fagerberg et al., 2012). In Peru, the gap is especially visible due to constraints in training, infrastructure, and financing.

This study analyzes the effect of digital innovation, operationalized through digital marketing, process automation, and data analytics, on the performance of university startups in Peru using the PLS-SEM technique.

Grounded in the prior literature and the proposed conceptual model, the study evaluates the following hypotheses.

H1: The intensity of digital marketing adoption is positively associated with startup competitiveness.

H2: The adoption of process automation is positively associated with operational efficiency.

H3: The adoption of data analytics is positively associated with strategic adaptability.

2. METHODOLOGY

This study adopted a quantitative, non-experimental, cross-sectional design to analyze the influence of digital innovation on the performance

of university startups in the Peruvian context. The partial least squares structural equation modeling (PLS-SEM) technique was applied, which is suitable for examining models with latent variables and complex causal relationships. The methodological approach enabled the estimation of the strength and direction of relationships among the dimensions of digital innovation, namely digital marketing, process automation, and data analytics, and the indicators of business performance, including operational efficiency, competitiveness, and strategic adaptability. The research was conducted between August and November 2024 in Metropolitan Lima, Peru, an environment characterized by a high concentration of university-based entrepreneurial initiatives. This location was selected due to its consolidated incubation ecosystems and the diversity of its emerging economic sectors. Two universities with recognized entrepreneurship programs participated in the study: Private University of the North and Autonomous University of Peru; Both institutions provided access to their updated databases of student-led startups, ensuring the relevance and currency of the information collected. The dataset was developed exclusively for this study and has not been previously used or published in any other scientific paper, thereby guaranteeing the originality and integrity of the empirical evidence.

The study population consisted of 120 university startups registered in the entrepreneurship and innovation programs of both institutions. From this total, 100 met the inclusion criteria and completed the survey, yielding a response rate of 83%, which is considered adequate for this type of research. The inclusion criteria established that startups must have been in continuous operation for at least six months and actively use digital tools in their business processes. Each startup was treated as a unit of analysis, and the information was provided by founders or management team members directly involved in strategic decision-making. The participating ventures belonged to the sectors of technology (37%), commerce (25%), education (18%), health (12%), and others (8%). This diversity ensured a representative sample across different levels of digital maturity. Descriptive data of the sample are summarized in Table 1.

Data collection was conducted entirely remotely through a self-administered online questionnaire created using Google Forms. This approach allowed for wider geographic coverage, facilitated participant engagement, and minimized potential interviewer bias. The form was distributed via institutional emails and through the incubation networks of the participating universities, and it remained available for three months. Periodic reminders were sent to encourage voluntary participation and to ensure a representative response rate. The online modality was consistent with the study's focus on innovation and the use of digital tools among entrepreneurs.

The data collection instrument consisted of a structured questionnaire comprising six thematic sections specifically designed for this study, based on an extensive review of recent literature on digital innovation, entrepreneurship, and organizational performance (Appendix A). The questionnaire was developed through a systematic and theoretically grounded process. First, theoretical constructions and key variables were identified from previous studies. Next, items from validated instruments were adapted to the Peruvian university context, with language adjustments to ensure cultural relevance. Redundant or ambiguous items were then removed to enhance clarity and conceptual precision. The final version included six sections: general characteristics of the startup, adoption of digital technologies, business performance, barriers to digital innovation, the founder's digital competencies, and institutional support within the entrepreneurial ecosystem. Each item was measured on a 5-point Likert scale (1 = very low, 5 = very high), and the average completion time was 10-12 minutes. The questionnaire is available from the corresponding author upon reasonable academic request.

To ensure the validity and reliability of the instrument, a two-stage validation process was conducted. In the first stage, content validation was performed through the review of three faculty researchers with expertise in innovation and entrepreneurship, who assessed the clarity, coherence, and relevance of the items. In the second stage, a pilot test was conducted with fifteen university entrepreneurs who shared characteristics with the target population. This process verified item comprehension and allowed wording adjustments, thereby improving the instrument's internal con-

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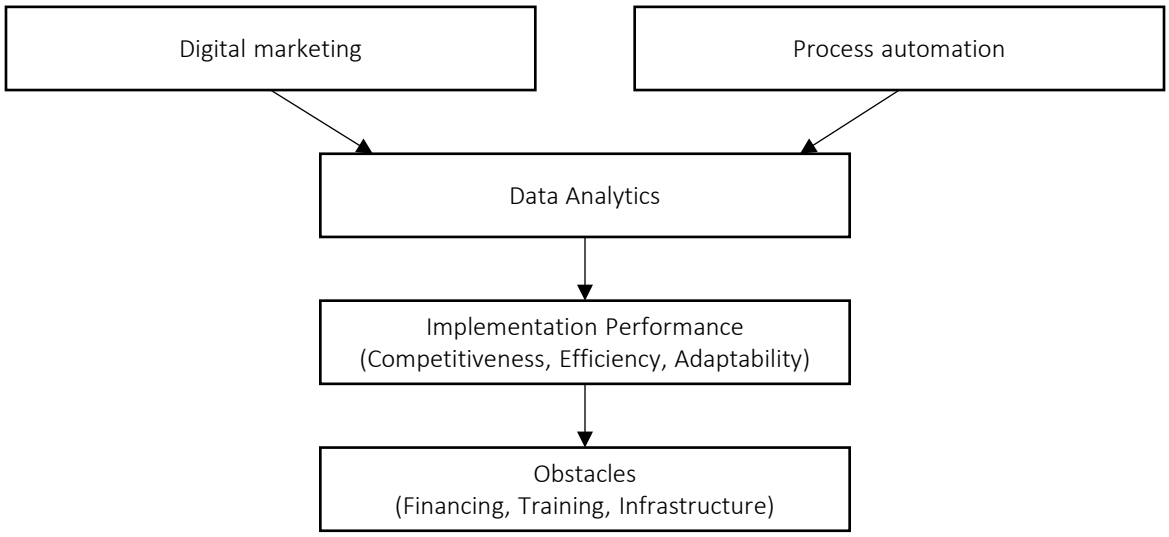

Figure 1. Conceptual model

sistency. Psychometric properties were subsequently evaluated using the PLS-SEM approach, yielding Cronbach's alpha and composite reliability values above 0.70, indicating satisfactory internal consistency. The Average Variance Extracted (AVE) exceeded 0.50, confirming convergent validity, while discriminant validity was established using the Fornell–Larcker and HTMT criteria.

Statistical analysis was conducted using SmartPLS 4 software, following a two-phase procedure. In the first phase, the measurement model was evaluated to verify the internal consistency of the latent constructs and to assess convergent and discriminant validity. In the second phase, the structural model was examined through path analysis using bootstrapping with 5,000 resamples, estimating the significance of path coefficients, *t*-values, *p*-values, and confidence intervals. The model's predictive power was assessed using R^2, Q^2, and effect size (f^2) indicators. In addition, descriptive analyses were performed to explore response distributions, and a post hoc statistical power analysis confirmed the adequacy of the sample size.

This methodological strategy ensured both the statistical robustness and theoretical coherence of the model. The conceptual framework guiding the empirical analysis integrated the three dimensions of digital innovation (marketing, automation, and analytics) and their combined effect on startup performance. Contextual factors such as financial constraints, limited technical training, and deficiencies in technological infrastructure were also considered, as these represent common challenges in entrepreneurial ecosystems within emerging economies. Figure 1 presents the proposed conceptual model.

The model links digital marketing, process automation, and data analytics to performance indicators (competitiveness, efficiency, adaptability) while considering contextual obstacles (financing constraints, limited technical training, and technological infrastructure).

This study fully complied with the ethical standards and research integrity policies of both participating universities. Formal approval from an ethics committee was not required, as the research involved minimal risk, voluntary participation, and no collection of personally identifiable information. Participation was entirely voluntary, and informed consent was obtained electronically before data collection. All procedures ensured anonymity, confidentiality, and secure data handling in accordance with institutional guidelines.

3. RESULTS

We report (i) measurement model assessment (reliability and validity), (ii) structural model evaluation (path coefficients and significance via 5,000 resamples), and (iii) descriptive evidence on barriers to digital transformation.

Table 1 summarizes the main demographic characteristics of the startups, helping contextualize the entrepreneurial profile within the Lima university ecosystem. Sixty-three percent of these startups are classified as small businesses with 1–10 employees, reflecting a lean organizational structure designed to reduce operating costs and increase flexibility in the early stages. Twenty-eight percent are medium-sized companies (11–50 employees), indicating moderate growth. At the same time, only 9% have more than fifty employees, suggesting limitations in access to financial, human, and technological resources that prevent more rapid expansion.

In terms of sectors of activity, technology accounts for the highest percentage of startups (37%), followed by commerce (25%) and education (18%). This distribution reveals a priority interest in industries highly influenced by digital transformation, where students find greater opportunities for innovation and the development of competitive solutions. On the other hand, sectors such as health (12%) and other areas (8%) have a lower participation, due to more complex infrastructure requirements or less availability of support networks for their development in the university environment.

Regarding entrepreneurial experience, 55% of founders have between 0 and 2 years of experience, indicating that the majority of ventures are driven by students or recent graduates with limited business backgrounds. This profile presents significant challenges in strategic management, decision-making, and sustainability, necessitating the implementation of support mechanisms, such as mentoring, incubation, and capacity-building programs. Thirty percent of entrepreneurs have intermediate experience (3–5 years), while only 15% have more than five years of experience, revealing a considerable gap in advanced business skills within this ecosystem.

Table 2 presents the frequency of use of various digital technologies among university startups, with a focus on three key tools: digital marketing, process automation, and data analytics. Digital marketing shows high usage, with an average of 4.35 on a scale of 1 to 5. This result suggests that startups recognize the value of digital marketing as a cost-effective and accessible means of increasing visibility, attracting customers, and strengthening their market position. The high adoption rate could be related to the low entry cost of many digital marketing tools and their relative ease of implementation compared to other technologies.

In contrast, process automation is used less frequently, with an average of 3.57. This figure indicates that although there is awareness of the benefits of automation for optimizing processes and improving operational efficiency, implementing these tools may be limited by barriers such as a lack of specific technical knowledge, high implementation costs, and the need for adequate technological infrastructure. The ability to automate routine tasks is crucial to improving productivity in small startups; therefore, the low use of this tool suggests an opportunity for strategic intervention.

Data analytics, with an average usage of 3.92, ranks at an intermediate level, indicating that these startups are beginning to leverage data to

Table 1. Demographic description of university startups

Characteristic	Category	Frequency	Percentage
Company size	Small (1–10 employees)	63	63
	Medium (11–50 employees)	28	28
	Large (more than 50 employees)	9	9
Business area	Technology	37	37
	Commerce	25	25
	Education	18	18
	Health	12	12
	Other	8	8
Founder's experience	Low (0–2 years)	55	55
	Medium (3–5 years)	30	30
	High (more than 5 years)	15	15

Note: Percentages rounded to the nearest whole number. *N* = 100.

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Table 2. Frequency of use of digital technologies in university startups

Digital technology	Low use (1-2)	Moderate use (3-4)	High use (5)	Average use
Digital marketing	10	45	45	4.35
Process automation	28	53	19	3.57
Data analytics	18	49	33	3.92

Note: Values represent the number of startups that reported each level of use. Likert scale from 1 (low use) to 5 (high use). *N* = 100.

make informed decisions and identify consumer behavior patterns and market trends. However, the level of adoption remains moderate, which may be related to a lack of advanced analytical skills or the unavailability of accessible analytical tools. Given the importance of data analytics for improving performance, this technology presents a development opportunity for university startups seeking to adapt quickly to market changes.

Table 3 examines the relationship between the level of adoption of digital technology and the performance of startups in terms of efficiency, competitiveness, and adaptability. The results indicate a positive and direct relationship between the intensity of digital technology use and the overall performance of startups. Startups with a high level of adoption use (5) obtained the highest scores in efficiency (4.60), competitiveness (4.40), and adaptability (4.50), highlighting how digital tools strengthen these companies' ability to respond to market demands, optimize their operations, and differentiate themselves from the competition.

The moderate level of adoption use (3–4) also shows acceptable performance, although significantly lower than the high level, with averages of 3.80 in efficiency, 3.50 in competitiveness, and 3.60 in adaptability. These figures suggest that although some digital tools are being implemented, there is still limited use that would allow startups to reap optimal benefits. Startups with low digital technology adoption (1–2) exhibit the lowest performance values across all three indicators, underscoring the competitive disadvantage of not adopting key technologies for growth.

These results confirm that digital technology is a crucial element for university startups, as it enhances their adaptability to environmental changes and improves their operational and commercial performance. Low digital technology adoption may be a limitation for some companies, underscoring the need for support programs that facilitate the effective implementation of digital tools.

Table 4 identifies the barriers perceived by university startups to the adoption of digital technology. Lack of funding is the most common obstacle, cited by 56% of new companies, underscoring the importance of financial resources in implementing and maintaining digital technologies. This result indicates that without access to affordable sources of funding, startups face significant constraints in modernizing and competing in a digitized market.

Lack of digital skills training is the second main barrier, at 22%, indicating a need for improved access to digital skills training. For university entrepreneurs, training in digital tools is not only desirable but essential for success in today's market, where the ability to manage technologies is increasingly critical. Limited access to technology and resistance to change also appear as barriers, albeit to a lesser extent (15% and 7%, respectively). These data suggest that, although technology is available, a lack of resources and training limits the ability to apply it. Resistance to change, although less common, may represent a cultural and mindset barrier that can be overcome through awareness and support programs.

Table 3. Performance of university startups by level of digital technology adoption

Level of technology adoption	Efficiency (mean)	Competitiveness (mean)	Adaptability (mean)
Low (1–2)	2.40	2.10	2.00
Moderate (3–4)	3.80	3.50	3.60
High (5)	4.60	4.40	4.50

Note: 1 = exceptionally low; 5 = extremely high.

Table 4. Analysis of barriers to digital innovation in university startups

Main Barrier	Frequency	Percentage
Lack of funding	56	56
Digital skills training	22	22
Access to technology	15	15
Resistance to change	7	7

Note: Percentages rounded to the nearest whole number.

Table 5 presents the results of the PLS-SEM analysis, showing significant relationships between the adoption of digital technologies and the performance of university startups. The relationship between digital marketing and competitiveness (path coefficient $\beta = 0.54$) was strong, with a $p < .001$, highlighting that digital marketing is a key factor for startups to improve their competitiveness in a highly dynamic and rapidly changing environment.

This reflects that digital marketing enables startups to establish a loyal customer base and stronger market positioning, thereby enhancing their competitive advantage.

The relationship between process automation and operational efficiency ($\beta = 0.41$, $p < .001$) indicates that automation is a significant driver of operational efficiency. Startups that implement automation technologies are more efficient in managing internal processes, which is critical for reducing costs and improving resource allocation. Finally, data analytics shows a significant association with adaptability ($\beta = 0.48$, $p < .001$), indicating that the use of data facilitates startups' ability to adjust to market needs and respond quickly to changes in demand.

Overall, the PLS-SEM results supported all proposed hypotheses ($p < .001$), confirming that digital marketing, process automation, and data analytics significantly enhances startup competitiveness, efficiency, and adaptability.

These findings highlight the significance of digital innovation in enhancing the performance of university startups in the Peruvian context. The adoption of digital technologies has a positive and direct impact on the competitiveness, efficiency, and adaptability of startups, with digital marketing being the most widely adopted tool, and a lack of financing being the most restrictive barrier. The PLS-SEM model confirms that digital innovation is a key factor in strengthening the position of these startups in a dynamic market. Based on these results, greater institutional support is recommended, especially in terms of access to financing and training in digital skills, to facilitate the digitization and sustainability of startups in the university environment.

4. DISCUSSION

The results validate that digital innovation has a direct, positive, and significant impact on the performance of university startups, particularly in terms of operational efficiency, market competitiveness, and adaptability. These findings reinforce the argument by Tidd and Bessant (2013), who maintain that digital capabilities are fundamental elements for sustainable and competitive development in contexts where structural constraints exist, such as those of emerging economies. These interpretations extend prior evidence by quantifying effects in a resource-constrained university setting.

The results are consistent with previous research highlighting the positive relationship between digital innovation and startup performance. Kraus et al. (2021) found that digital transformation significantly enhances the competitiveness and efficiency of entrepreneurial ventures in emerging economies. Similarly, Elia et al. (2020) demonstrated that the adoption of digital tools fosters innovation capabilities and market adaptability among university startups. In line with Cheng et

Table 5. PLS-SEM results: Digital innovation → startup performance

Relationship between variables	Path coefficient (β)	t-value	p-value	Significant result
Digital marketing → Competitiveness	0.54	8.92	p < .001	Yes
Process automation → Efficiency	0.41	6.11	p < .001	Yes
Data analytics → Adaptability	0.48	7.23	p < .001	Yes

Note: Results are based on structural equation models. All relationships are statistically significant at $p < .001$.

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al. (2023), our findings confirm that digital marketing and data-driven management contribute to strategic growth and operational performance. However, unlike those studies, this paper identifies financial constraints as the most critical barrier to digital transformation within the Peruvian university ecosystem.

Among the variables studied, digital marketing proved to have the greatest impact on performance. Its impact translates into greater visibility, audience segmentation, immediate consumer feedback, and customer loyalty at low cost, which represents a key advantage for startups with limited resources (Arnold & Wade, 2015; Maritz & Donovan, 2013). This evidence is consistent with previous studies that highlight the role of digital marketing as a tool for democratizing market access (Davidsson, 2016), which is especially relevant for entrepreneurs without commercial experience.

On the other hand, process automation showed notable effects in improving operational efficiency. The ability to eliminate repetitive tasks, minimize errors, and optimize resources aligns with the arguments of Gunday et al. (2011), who recognize automation as a key factor in the competitiveness of small businesses. However, it was also evident that its adoption is still in its infancy in many initiatives, due to a lack of technical training and the limited availability of platforms adapted to the Peruvian university environment (Zahra & Nambisan, 2012; Caloffi et al., 2023).

Data analytics, meanwhile, proved to be a facilitator of strategic adaptability. Its implementation enables startups to analyze behavior patterns, track performance indicators, and refine their business models based on evidence. As Fagerberg et al. (2012) state, analytical capacity enhances an organization's response to environmental changes, which is especially valuable in dynamic markets. However, data analytics skills are still limited among many university entrepreneurs, which reduces the potential impact of this technology (Liu et al., 2021; Álvarez & Seclén, 2023).

The study also identified significant structural barriers that limit digital transformation in the university environment. The most frequently mentioned by respondents were lack of funding, restricted access to specialized training, and weak technological infrastructure. These barriers align with those already described by Hair et al. (2021) and Cunneen et al. (2007), serving as a warning to institutional actors responsible for promoting student entrepreneurship. At the national level, PRODUCE (2020) also warns of the urgent need to strengthen innovation support systems.

In this context, the role of universities as catalysts for the entrepreneurial ecosystem assumes special significance. Beyond their educational function, they must provide incubation spaces, mentoring networks, strategic alliances, and an institutional environment conducive to innovation. As pointed out by Autio et al. (2014) and Bogers et al. (2018), the entrepreneurial ecosystem must be built collaboratively among academia, the private sector, and the state. This coordination helps overcome structural barriers and promote a sustainable digital culture within the university community (Acs et al., 2014; Del Carpio Gallegos & Seclén-Luna, 2022).

Despite its contributions, the study has certain limitations. It is based on data collected in a single geographical region and at two universities, which may limit the generalizability of the findings. Future research should expand the sample to include universities in other areas of Peru or similar Latin American contexts. In addition, this study employed a cross-sectional design; longitudinal studies would provide valuable information on how digital adoption evolves over time.

Another promising avenue for future research includes examining startups in specific sectors or comparing ventures across disciplines (e.g., engineering versus humanities) to assess whether the impact of digital innovation varies by context. Other studies could also evaluate the effectiveness of specific training programs or university initiatives aimed at improving digital skills.

This study provides contextualized empirical evidence that helps fill a gap in the literature on digital innovation in university startups in Latin America. While many previous papers focused on more established or corporate ecosystems, we focus on an underserved segment: student-led ventures in regions with limited access to capital

and technology. As Tether and Tajar (2008) and Wright et al. (2017) argue, understanding entrepreneurial dynamics in real-world contexts enables the design of more inclusive and effective policies tailored to local challenges.

Overall, the results of this study highlight that digital innovation is a decisive factor for enhancing the performance and competitiveness of student startups in emerging economies. These findings align with recent evidence by Alshebami et al. (2025), who demonstrated that access to technology and digital literacy significantly influence entrepreneurial intentions and empowerment, particularly among women in developing countries. In this regard, the current analysis reinforces the global understanding that digital capabilities are essential for fostering innovation, adaptability, and long-term sustainability among new ventures, especially within the context of higher education institutions.

Taken together with recent evidence, our findings suggest that key digital capabilities such as marketing, automation, and analytics enhance entrepreneurial intentions and self-efficacy, which in turn strengthen operational and market performance and contribute to long-term business sustainability among SMEs (Suprayitno et al., 2025).

CONCLUSION

This study examined whether digital marketing, process automation, and data analytics enhanced the performance of student startups in Peru using partial least squares structural equation modeling (PLS-SEM).

The findings confirmed that digital marketing positively influences competitiveness ($\beta = 0.54$, $p < .001$), process automation improves operational efficiency ($\beta = 0.41$, $p < .001$), and data analytics strengthens strategic adaptability ($\beta = 0.48$, $p < .001$). Descriptive evidence also revealed that limited financing and insufficient digital training are major barriers to digital transformation among university-based startups.

Overall, digital innovation constitutes a key driver of entrepreneurial performance in resource-constrained academic ecosystems. Universities and incubators should therefore integrate practical digital skills training, foster automation and data-driven decision-making, and ensure accessible financing mechanisms to strengthen startup competitiveness and sustainability.

AUTHOR CONTRIBUTIONS

Conceptualization: Luis Miguel Olórtegui-Alcalde.
Data curation: Luis Miguel Olórtegui-Alcalde.
Formal analysis: Franklin Cordova-Buiza.
Funding acquisition: Franklin Cordova-Buiza.
Investigation: Luis Miguel Olórtegui-Alcalde, Franklin Cordova-Buiza.
Methodology: Luis Miguel Olórtegui-Alcalde.
Project administration: Franklin Cordova-Buiza.
Resources: Luis Miguel Olórtegui-Alcalde.
Software: Franklin Cordova-Buiza.
Supervision: Franklin Cordova-Buiza.
Validation: Luis Miguel Olórtegui-Alcalde.
Visualization: Luis Miguel Olórtegui-Alcalde.
Writing – original draft: Luis Miguel Olórtegui-Alcalde.
Writing – review & editing: Franklin Cordova-Buiza.

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APPENDIX A

Table A1. Full questionnaire

Section 1. General characteristics of the startup					
University of origin:					
Main economic sector:					
Years of continuous operation:					
Total number of team members:					
Role of the respondent within the startup:					
Previous experience in management or entrepreneurship (in years):					
Section 2. Adoption of digital technologies					
Items	**1**	**2**	**3**	**4**	**5**
Our company uses digital marketing tools (social media, web positioning, online campaigns).					
We have implemented automated processes to improve operational efficiency.					
We use data analytics to support strategic decision-making.					
We employ cloud-based or collaborative platforms for task management.					
We consider digital transformation a strategic priority in our business.					
Section 3. Perceived business performance					
Items	**1**	**2**	**3**	**4**	**5**
The adoption of digital tools has improved our operational efficiency.					
Technological innovation has increased our competitiveness in the market.					
We have achieved greater customer satisfaction through digital solutions.					
Digitalization has enhanced our ability to adapt to environmental changes.					
The use of technology has contributed to improving the profitability and sustainability of the business.					
Section 4. Barriers to digital innovation					
Items	**1**	**2**	**3**	**4**	**5**
A lack of financing limits the implementation of digital tools.					
We do not have personnel sufficiently trained in technology.					
The digital platforms available do not meet the needs of our business.					
There is internal resistance to change or to adopting new technologies.					
The university's technological infrastructure is insufficient to support innovation.					
Section 5. Founder's digital competencies					
Items	**1**	**2**	**3**	**4**	**5**
I have basic knowledge of digital tools applied to marketing.					
I know how to use data analytics or business intelligence applications.					
I am capable of leading automation processes in my startup.					
I keep myself updated on new technological trends.					
I consider that my digital competencies positively influence the performance of my business.					
Section 6. Institutional and ecosystem support					
Items	**1**	**2**	**3**	**4**	**5**
My university offers programs or workshops that promote digital transformation.					
We have received advisory or mentoring support from university or external incubators.					
There is effective collaboration with other entrepreneurs or partner institutions.					
Institutional policies encourage innovation and digital entrepreneurship.					
The university's entrepreneurial ecosystem contributes to the growth of our startup.					

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